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RDECOM-TARDEC Joint Center for Robotics (JCR)

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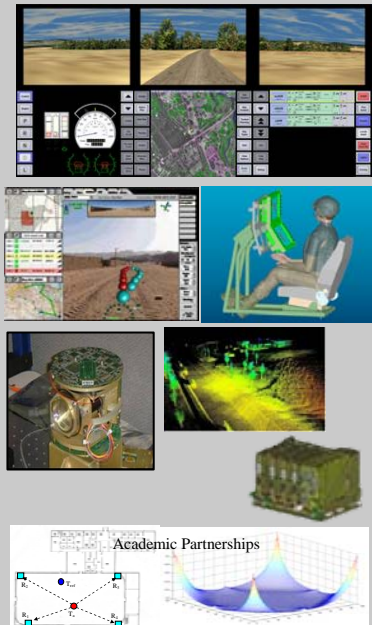
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Mission

Integrate, Explore, and Develop Robotics, Network and Control Components with a Focus on Customer Driven Requirements to Provide Full System Solutions to the War Fighter

Technology Components



Integration

Demonstrators



RF Stryker



SME
Defined
Scenarios

Military Relevant Test & Experimentation



Robotics Collaboration and RVCA ATO Experimentation



Convoy Active Safety Technologies
War Fighter Experimentation #1

Tech
Transfer

Transition and Requirements Development



Initial
Capabilities
Document
(ICD)

FCS MULE



FCS ANS



FCS JTRS



Current Force Convoy Operations



Integration Technology Development Lessons
Learned to Enable Early Technology Insertion

Enabling Technologies

Making the robots work well with others

Today: Robots used individually and independently

Vision: Robots that are fully networked and collaborative

Collaborative Unmanned Systems

Making the ... robots

Today: Robot operations confined to limited environments

Vision: Robots that are able to operate in any environment at any time

Autonomous Operations

Making the robots smarter

Today: Human input required to control every aspect of robot

Vision: Robots that are able to think and act intelligently and independently

User Interfaces

Making the robots easier to use

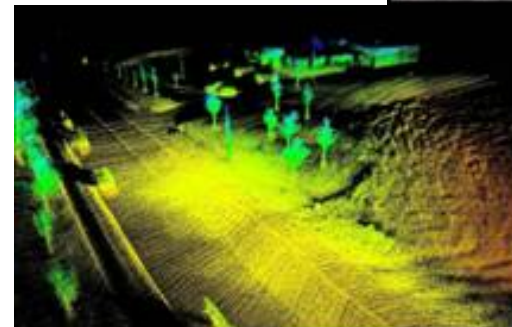
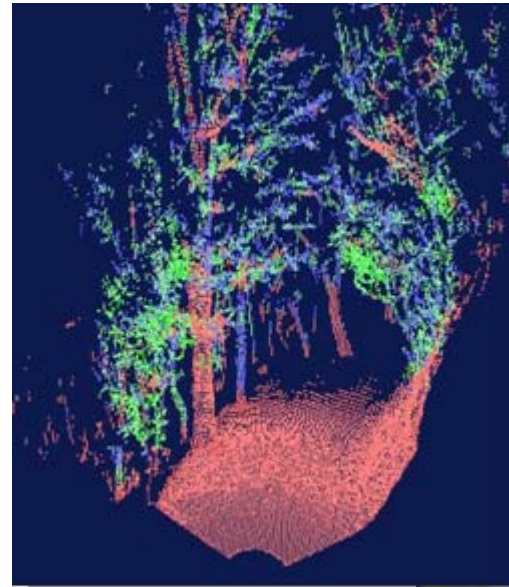
Today: Robot control requires specialized equipment and training

Vision: Robots that are intuitively easy to command and control

Advanced Platform Design

Research Topics – Potential Shortfalls

- Sensors – extended range & resolution
- Sensors – all weather sensing/obscurants
- Sensors – reduced size
- Software – Terrain classification, especially at extended range
- Software – Feature classification, especially at extended range
- Software – Detection, classification, tracking of moving vehicles, people, & animals from a moving vehicle (object association/partial obscuration)
- Software – Detection of moving & stationary people, often partially obscured or camouflaged
- Software – Stand-off classification of mud or water – estimate of surface supportability/trafficability



Research Topics – Potential Shortfalls

Vehicle Intelligence

- Ability to adapt to changing environment & learn from prior experience or act based upon general guidance
- Ability to project future activity or courses of action by others and plan accordingly
- Ability to understand vehicle health and modify plans accordingly

Tactical Behavior

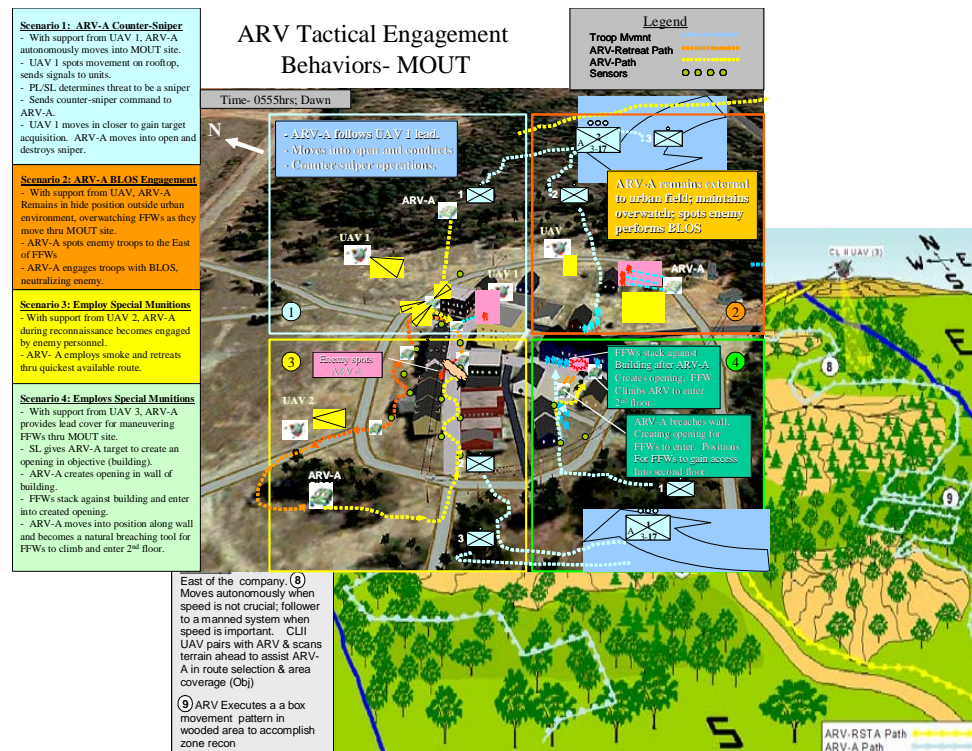
- Mimic the behavior of Soldiers under similar conditions
- Continue autonomous operation during prolonged communications outages
- Self-protection

Collaboration

- Shared situational awareness
- Teaming – robot/robot and robot/Soldier

Mission Specific Behaviors

- RSTA
- Force Protection
- Material handling/delivery



Research Topics – Potential Shortfalls

Operator Control

- Situational awareness of what's going on around the robot/operator intervention
- Scalable interfaces – from MGVT to dismount
- Operator workload in realistic tactical environments
- Operator span of control
- Alternative control modes (voice/gesture)
- Hands free, heads up display and control

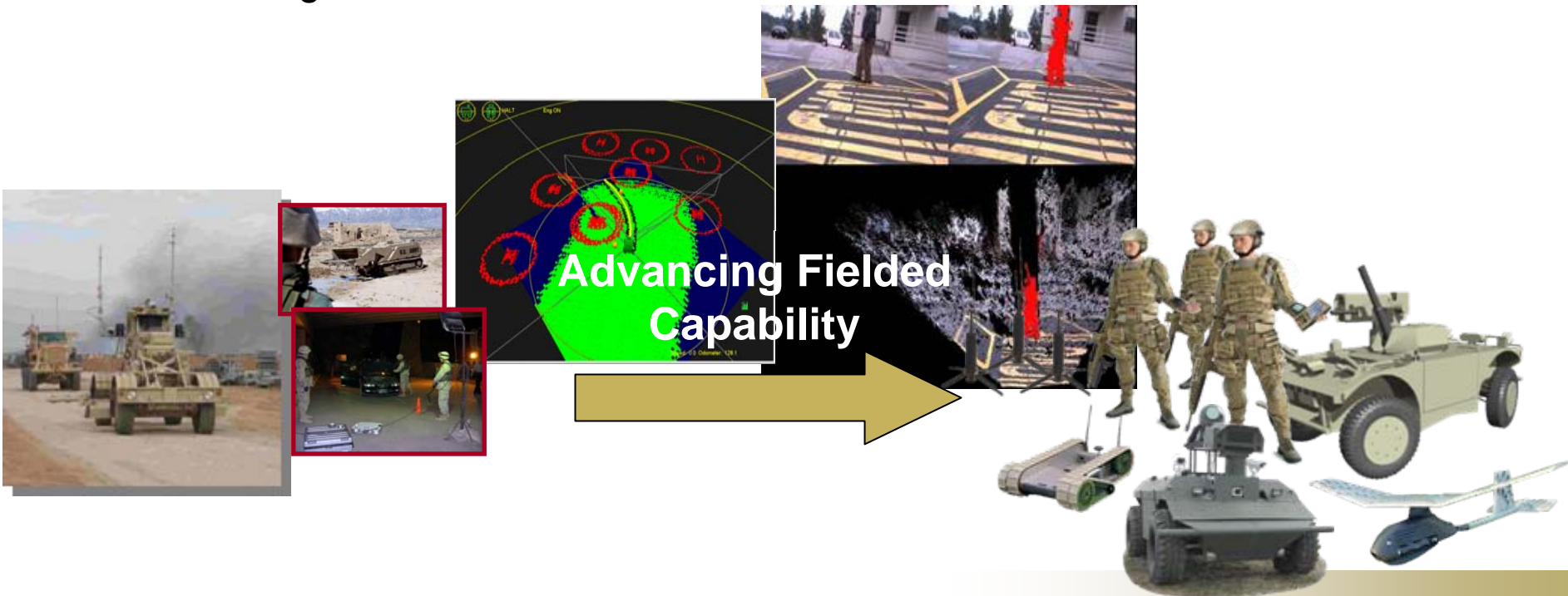
Command Integration

- Fusion of local situation awareness information with the Common Operating Picture



Research Topics – Potential Shortfalls

- Autonomous Vehicle safety
- Autonomous Weapon safety
- Platform – modularity; shape shifting; micro/miniaturization; bio-mimetic; health maintenance/ prognostics/ self-healing;
- Low SWAP, high bandwidth data links
- High density power sources
- Network integration



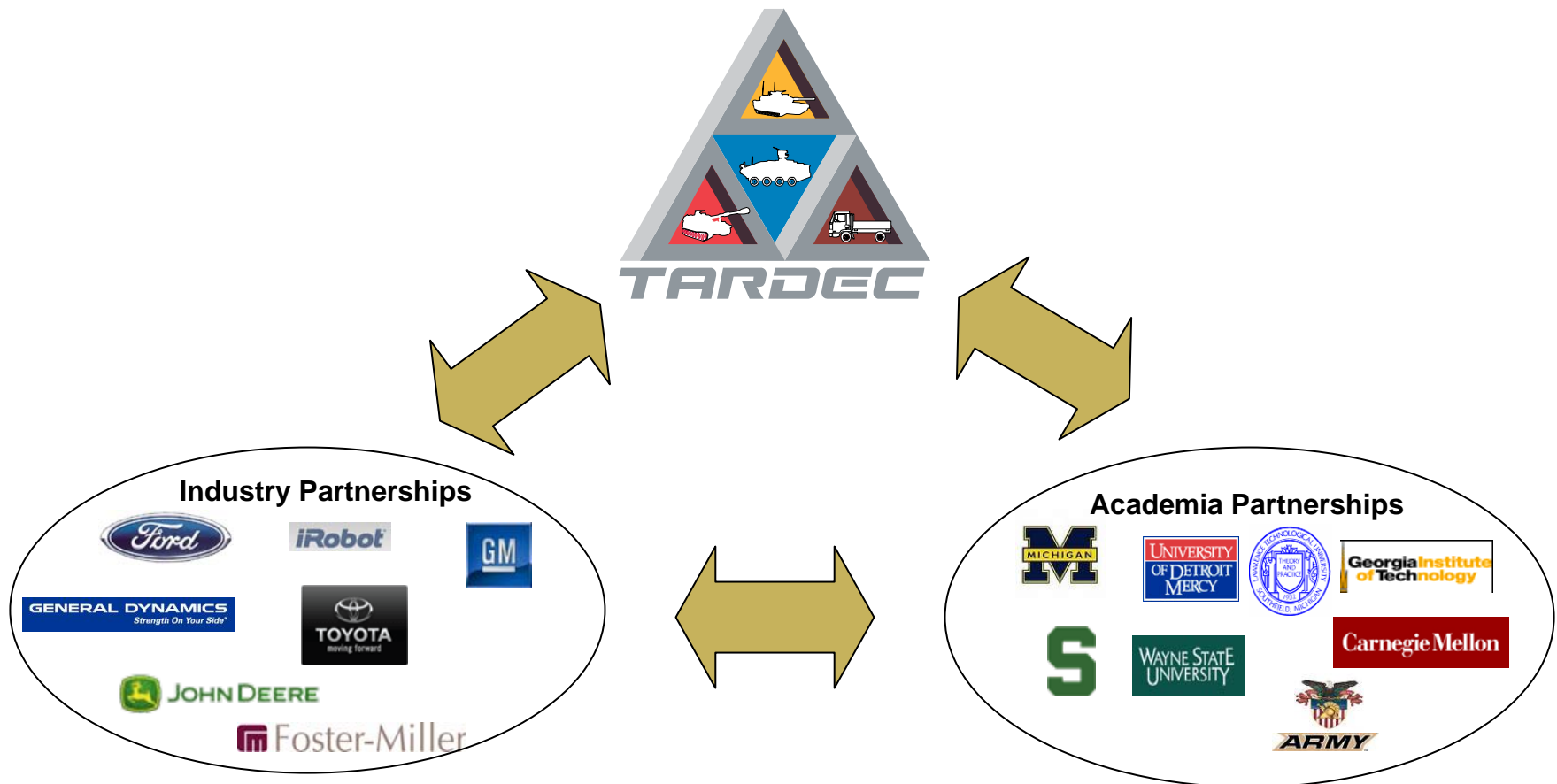
Hard Off-road Problems

- Very cluttered environments
- Mud, ice, snow, gravel and other traction problems
- Deep water
- Sharp rocks, rebar, curbs
- Tank traps
- Wire, posts, and fences
- Hidden hazards: rocks and holes
- Fog, dust, smoke, rain

Hard On-road Problems

- Very busy environments
- Potholes
- Other vehicles
- Poor lane markings
- Traffic signals
- Pedestrians
- Animals
- Road work/construction

Summary of Completed and Proposed Activities



Operations

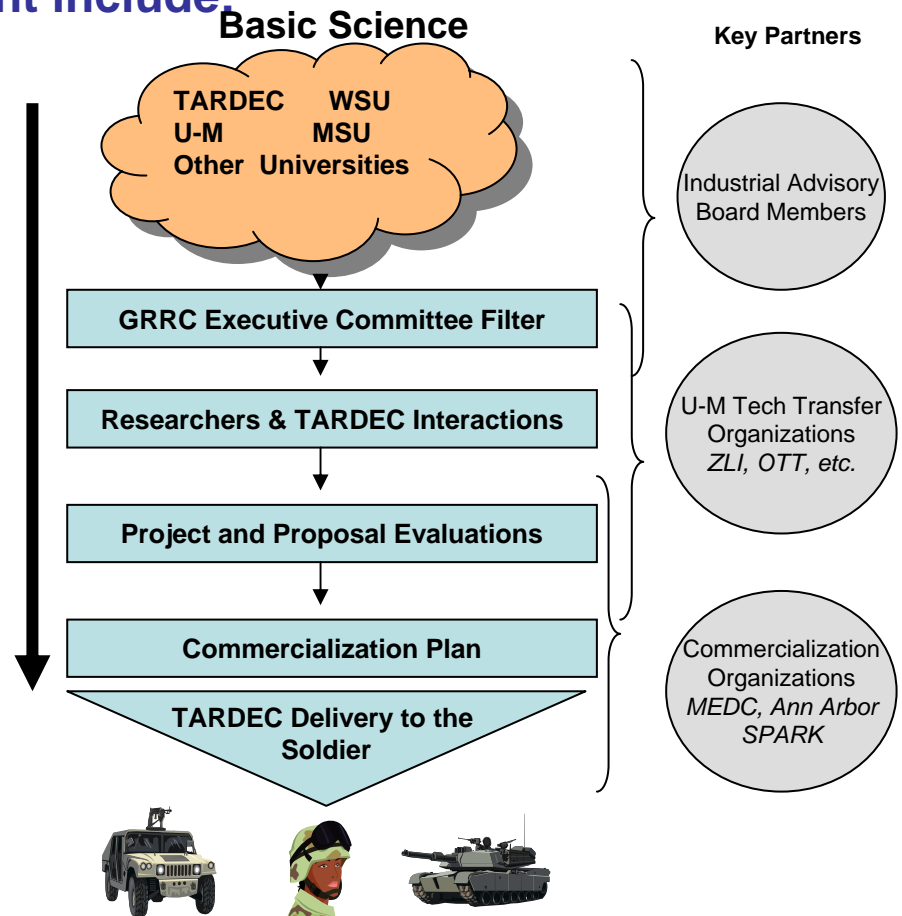
“Directed” Research designed to deliver to the soldier

Goal of the GRRC

To develop *unmanned ground vehicle and robotics research expertise and curricula*, and to graduate students with that expertise, at a consortium of universities in support of growing TARDEC activities in those areas, to increase the impact and speed of delivering cutting edge technology readiness for the soldier.

Key Elements of the Center Management include:

Joint Management	<ul style="list-style-type: none"> Strategic direction of the center such as research areas, etc will be managed jointly by TARDEC, Industry, and Universities
Vetted Projects	<ul style="list-style-type: none"> Research Areas and projects will be critically examined for relevance and likelihood of impacting the soldier
Focus on the soldier	<ul style="list-style-type: none"> All aspects of the center will reinforce timely delivery of new/break through technology and demonstration projects to TARDEC and the soldier (short term immediate needs and mid-long term thrusts)
Measurable results	<ul style="list-style-type: none"> Strong feedback and program management techniques will be employed to measure results and adapt when appropriate



Research Areas

Objectives, Deliverables & Timelines

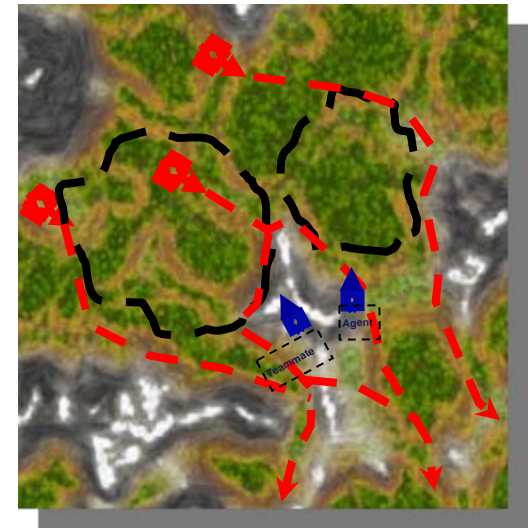
RA #1: UGV Architecture for Intelligence, Vision & Man-Machine Interface

Objectives: Research to support a wide spectrum of autonomy robot/human interaction

- Human control of unmanned vehicles.
- Adjustable autonomy and cooperative control:
- Close to full autonomy within the context of safe operations

Tasks & Deliverables

QUARTER	TASKS & DELIVERABLES
1 st	<ul style="list-style-type: none">➤ Issue RFP for research projects➤ Evaluate simulations➤ Initiate analysis of requirements for safe operations.
2 nd	<ul style="list-style-type: none">➤ New projects based upon RFP Evaluation➤ Develop interfaces to simulation and robot➤ Analyze alternative tele-operation controls and technologies to support safe operations and adjustable autonomy
3 rd	<ul style="list-style-type: none">➤ Continue development of interfaces➤ Initiate development of demonstrations
4 th	<ul style="list-style-type: none">➤ Report on UGV architecture and complete demonstrations



Target Areas Addressed:

- Safe Operations
- Tactical Behaviors
- Autonomous Controls
- Tele-Operation
- Machine-Human Interfaces

Research Areas

Objectives, Deliverables & Timeline

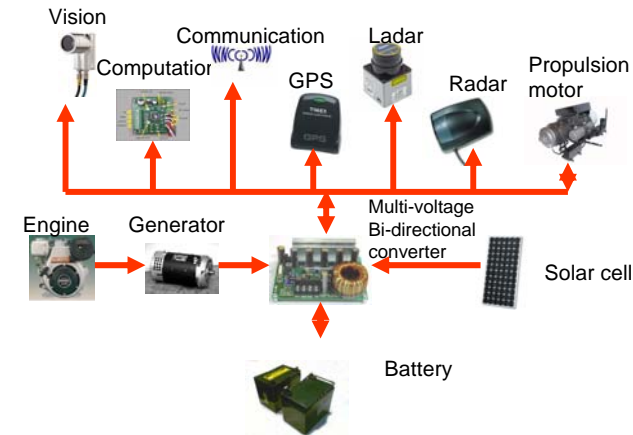
RA#2 UGV Energy, Power and Mobility

Objectives: Develop fundamental knowledge and deploy state of the art technologies to:

- Enhance the mission quality and mobility of ground robots
- Improve energy storage, harvesting, utilization
- Enhance system adaptation and integration of power and energy

Tasks and Deliverables

QUARTER	TASKS & DEVLIVERABLES
1 st	<ul style="list-style-type: none"> ➤ Conduct pilot projects ➤ Initiate energy analysis & data collection for critical systems.
2 nd	<ul style="list-style-type: none"> ➤ Establish flexible energy system architecture ➤ Initial energy sizing spec. for the target mobile robot platform ➤ New projects selected and launched based upon
3 rd	<ul style="list-style-type: none"> ➤ Initial energy system integration model ➤ Simulation demonstration of pilot project results
4 th	<ul style="list-style-type: none"> ➤ Report and demonstrations of pilot projects



Army/Industry Benefits:

This research area will develop key enabling technologies to improve the mobility and autonomous operation of mobile robots.

Research Areas

Objectives, Deliverables & Timelines

RA#3 UGV Dynamics and Navigation, Including Ground and Vehicle Interface

Objectives: Develop new models for the dynamics of Unmanned Ground Vehicles

- Includes interactions at the ground vehicle interface for traction, acceleration, and cornering
- Develop methods, algorithms, and techniques for UGV navigation through uncertain environments
- Terrain model-building, optimal path planning, tracking of dismounted soldiers,
- Identification of humans in the path.

Tasks and Deliverables

QUARTER	TASKS & DELIVERABLES
1 st	<ul style="list-style-type: none"> ➤ Improved PDR algor. & UWB Radio Characterization ➤ Algorithms to fuse DGPS, LADAR, compass, and optical images to create a local feature map
2 nd	<ul style="list-style-type: none"> ➤ Computer simulation environment for integration ➤ Register local maps to produce a global shared map
3 rd	<ul style="list-style-type: none"> ➤ Select robot platform for integration of safe sensors ➤ Multi-agent network to share local mapping data
4 th	<ul style="list-style-type: none"> ➤ Upgrade TACOM's PDR system ➤ Sensor fusion for mobile UWB networks ➤ Implement global mapping algorithms on testbed



Army/Industry Benefits:

- Improved safe operations for UGVs in cooperation with humans
- Improve the 360 degree awareness
- Enhanced platform mobility.

Research Areas

Objectives, Deliverables & Timelines

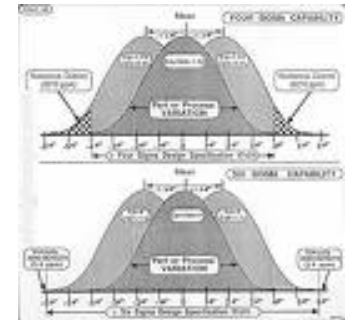
RA# 4UGV Reliability and Manufacturing

Objectives: Dramatically increase the reliability of unmanned vehicles

- Understand low values of mean-time-between-failure
- Focus on the reliability and manufacturing of robots and autonomous ground vehicles
- Address research needs the field of robotics with existing strengths automotive manufacturing

Tasks and Deliverables:

QUARTER	TASKS & DELIVERABLES
1 st	<ul style="list-style-type: none"> ➤ Issue RFP for research projects in Reliability and Manufacturing of UGV ➤ Analysis of US Army data on UGV reliability
2 nd	<ul style="list-style-type: none"> ➤ New projects based upon evaluation/selection of proposals submitted in response to RFP ➤ Continued Analysis of US Army data on UGV reliability
3 rd	<ul style="list-style-type: none"> ➤ Define UGV reliability and manufacturing research agenda
4 th	<ul style="list-style-type: none"> ➤ -Report on UGV reliability and manufacturing



Army/Industry Benefits:

- Improved Mean Time to Failure for unmanned vehicles
- Recommendations to ensure reliability in the manufacturing of unmanned ground vehicles can be developed based upon previous work on automotive systems
- A defined research agenda for reliability and manufacturing of autonomous vehicles

Research Areas

Objectives, Deliverables & Timelines

RA#5 TESTBEDS: System & Subsystem Integration, Sensor Fusion & Demo

Objectives: Test & demonstrate robotics technologies on fully functional mobile robots.

- Integrate diverse ground robotics technologies developed under Research Areas 1-4 to demonstrate and highlight their collective strength.
- Deliver demonstration units, models, and platforms to TARDEC for field evaluation

Task and Deliverables:

QUARTER	TASKS
1 st	<ul style="list-style-type: none">- Robot A and Robot B platform acquired.- Robot A fully operable with original manufacturer's software
2 nd	<ul style="list-style-type: none">- Robot A low level components controllable directly, by-passing original manufacturer's software- Robot B "drive-by-wire" conversion started
3 rd	<ul style="list-style-type: none">- Robot B "drive-by-wire" conversion completed
4 th	<ul style="list-style-type: none">- Low-level control software for Robot A completed- Low-level control software for Robot B completed

Talon



Packbot



Gator



**Expected Demo.
Platforms**

Army/Industry Benefits:

- Substantially more research accomplishments for the same amount of funding
- Leverages and coordinates research areas
- The demo platforms will be equipped with those general perception capabilities that are needed for autonomous behaviors